# Lecture Outline

**Sensation & Perception**

- **The Basics of Sensory Processing**
  - **Eight Senses**
  - Bottom-Up and Top-Down Processing

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# Basic Definitions

- **Sensation**: stimulation of sense organs by sensory input
- **Transduction**: process by which a stimulus is converted into a neural impulse
  - Cells of sensory organ stimulated by sensory input
  - Stimulation converted into neural impulse
  - Neural impulse passed from cells of sensory organ to brain
- **Perception**: process by which the sensory inputs are organized and interpreted
- **Psychophysics**: the study of how physical stimuli are translated into psychological experience

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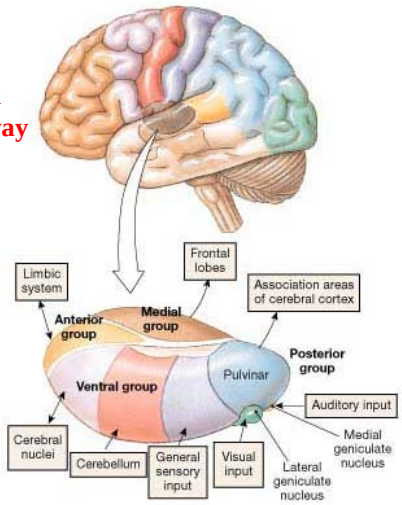
SHOUT
SHARE
IT

## Human Senses

1. Vision
2. Hearing
3. Touch
4. Taste
5. Smell
6. Vestibular sense
7. Kinesthesis
8. Skin senses

**Almost all sensory input routed through the thalamus on its way to specific regions of the brain**

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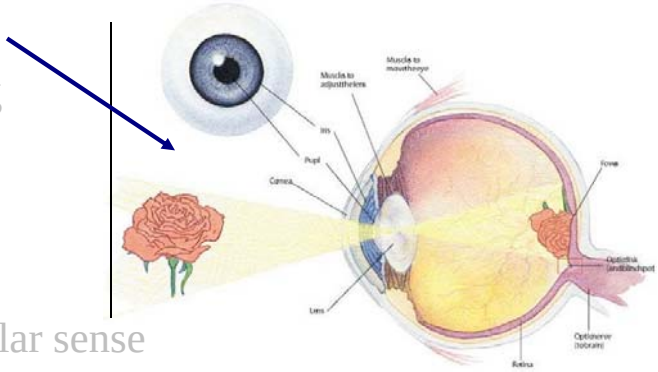

**Input sent from retina down the optic nerve to the lateral geniculate nucleus of the thalamus and then onto the primary visual area (occipital lobe)**

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## Human Senses

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**Sound waves cause vibrations in the ear which reach the cochlea and are sent to the primary auditory area (temporal lobe)**

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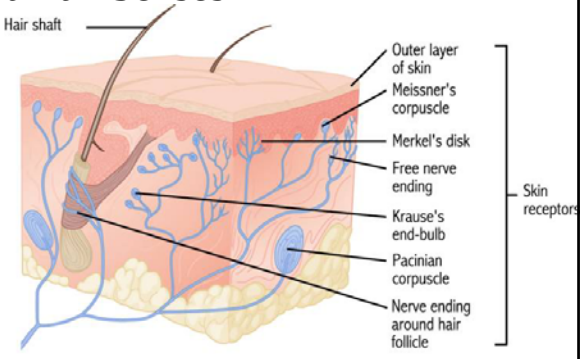


**Touch receptors send information up the spinal cord to the somatosensory area (parietal lobe)**

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## Human Senses

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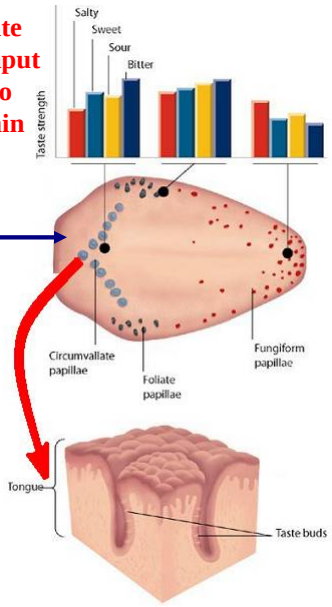
**Soluble chemicals activate taste buds which send input through cranial nerves to limbic regions of the brain**

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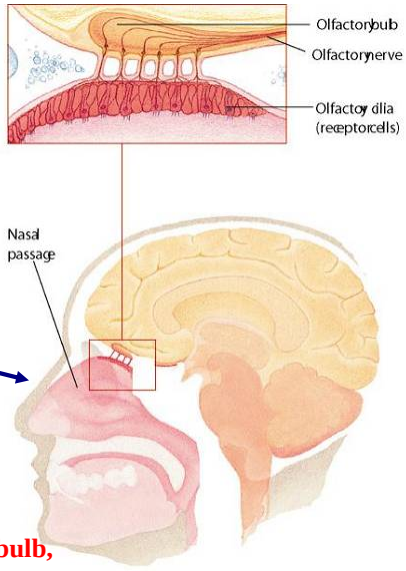
**Olfactory receptors in nasal passage sensitive to chemicals in air.**




**Input sent along olfactory nerve to olfactory bulb, and <u>does not pass</u> through the thalamus.**

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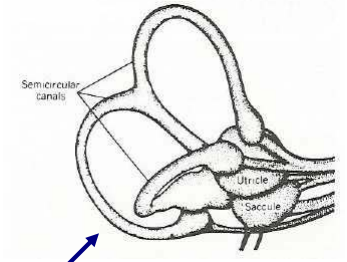


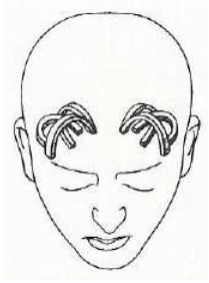

**Monitors balance using fluid-filled semicircular canals**

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## Human Senses

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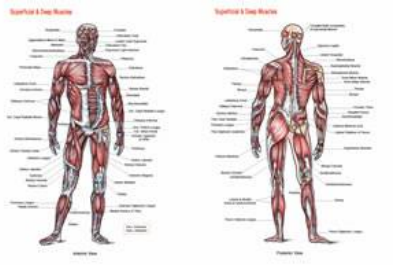
**Keeps track of position of body (e.g., limbs) in space sent**



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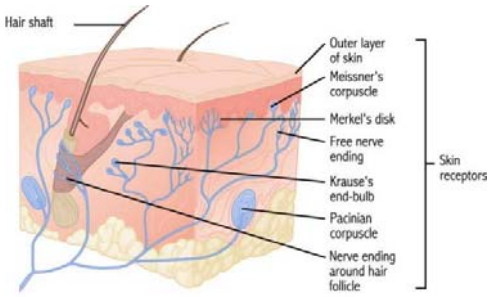


**Besides receptors for sense of touch, the skin gathers information on pain and temperature**

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## Lecture Outline

**Sensation & Perception**

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  - Eight Senses
  - **Bottom-Up and Top-Down Processing**

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## Sensory Input: Two Schools of Thought

1. Empiricism

2. Nativism

If a tree falls in the woods…

**<u>Distal stimulus</u> = Sight of tree, sound of falling, texture of solid object, etc.**

**<u>Proximal stimulus</u> = Input created at sensory receptors in eyes, ears, and finger tips, respectively**

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## Sensory Input: Two Schools of Thought

- Empiricism → We create representations of the world as our senses experience new things

**<u>Bottom-up processing:</u> sensory inputs pieced together to gradually build knowledge of an object (a.k.a. representation)**

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## Sensory Input: Simplifying the Schools of Thought

- Nativism → We recognize objects as we come across them because our senses are able to classify everything, even things that we might not have experienced before

**Top-down processing: sensory inputs activate overall representation of object, with the smaller units of the object emerging afterwards**

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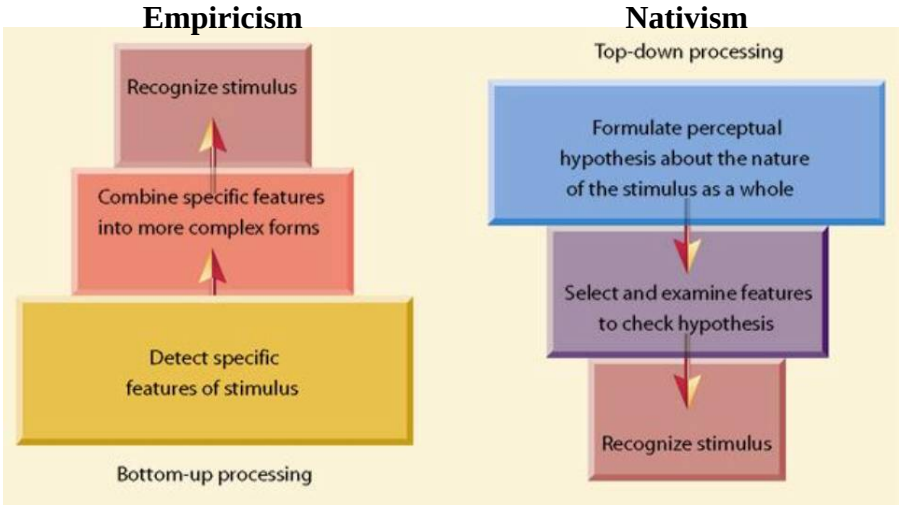
## Organization of Sensory Input


Empiricism
Nativism
Top-down processing
Recognize stimulus
Combine specific features into more complex forms
Detect specific features of stimulus
Bottom-up processing
Formulate perceptual hypothesis about the nature of the stimulus as a whole
Select and examine features to check hypothesis
Recognize stimulus

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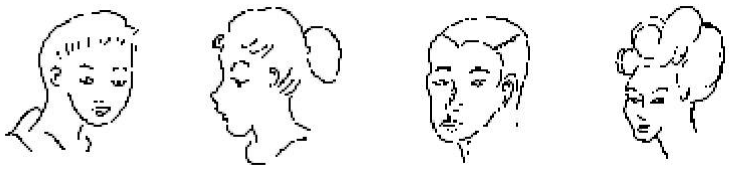
## What do you see? (#1)



What is this?

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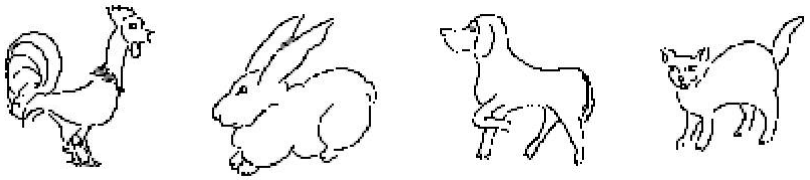
## What do you see? (#2)



What is this?

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## Visual Top-Down Processing

**Faces**

**Animals**

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## What do you hear?

***Stairway to Heaven*** from Led Zeppelin's **IV** album

Regular Lyrics:

"If there's a bustle in your hedgerow, don't be alarmed now. It's just a spring clean for the May queen. Yes there are two paths that you can go by, but in the long run there's still time to change the road you're on."

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## What do you hear?

***Stairway to Heaven*** from Led Zeppelin's **IV** album

Play in reverse…

Write down anything that you can understand.

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## Auditory Top-Down Processing

***Stairway to Heaven*** from Led Zeppelin's **IV** album

Suggested lyrics in reverse…

"Oh here's to my sweet Satan. The one whose little path would make me sad, whose power is satan. He'll give those with him 666. There was a little tool shed where he made us suffer, sad Satan."

**Top-down processing**

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## Lecture Outline

**Sensation & Perception**

- Hearing
- Vision

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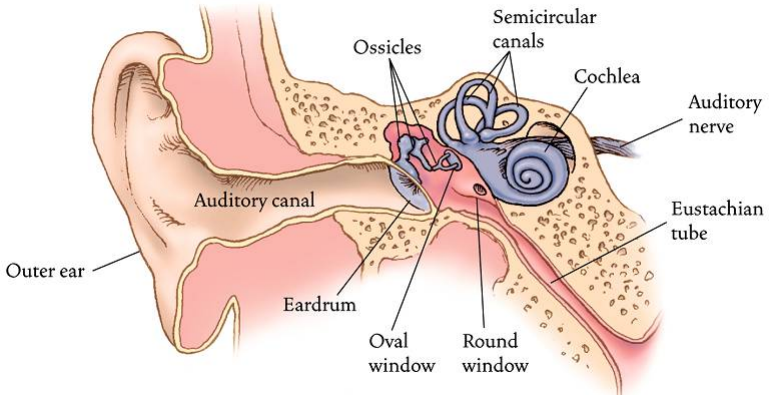
Gather sound waves with the ear

Distal Stimuli = **sound waves** (vibrations of air molecules)

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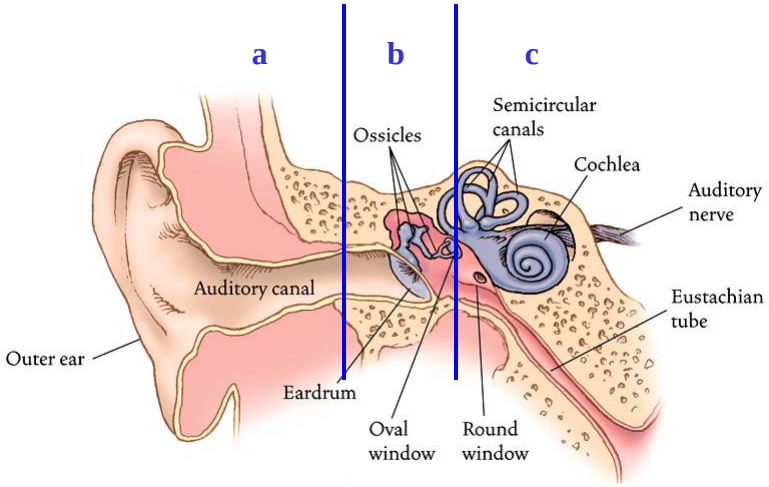
Gather sound waves with the ear

Ear divided into 3 sections: (a) outer, (b) middle, and (c) inner ears

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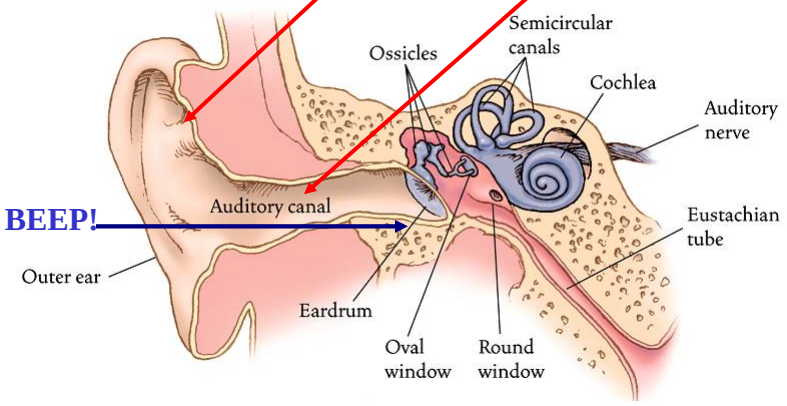
Gather sound waves with the ear

The outer ear consists of the pinna and the auditory canal

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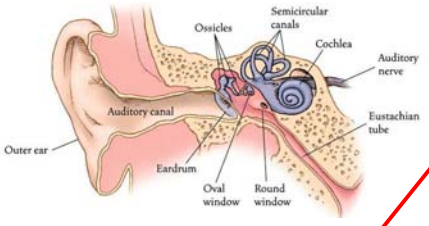
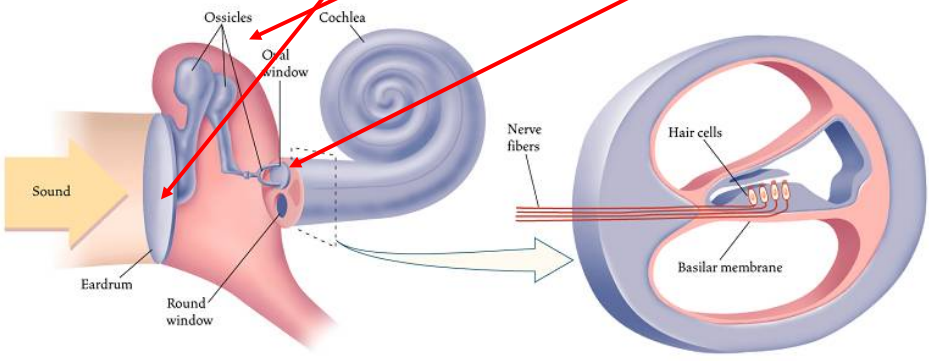
Sounds waves travel to the ear drum

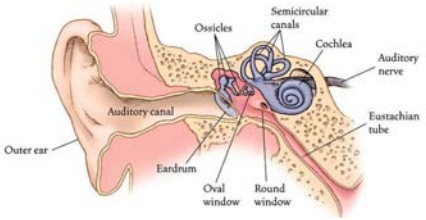



And cause the ear drum to vibrate

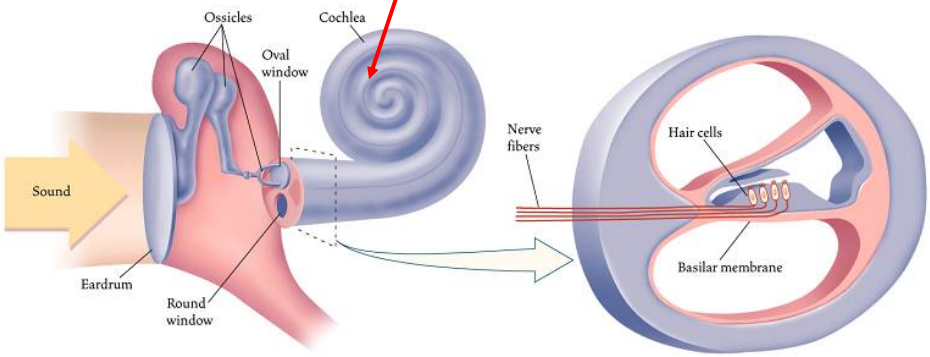
Vibrations in the ear drum cause the bones of the middle ear (ossicles) to push up against the oval window



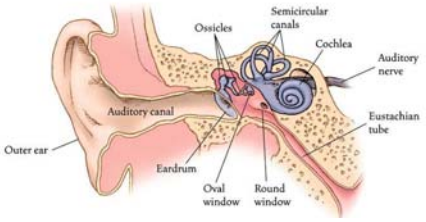
From the ear drum, sound waves travel to the cochlea



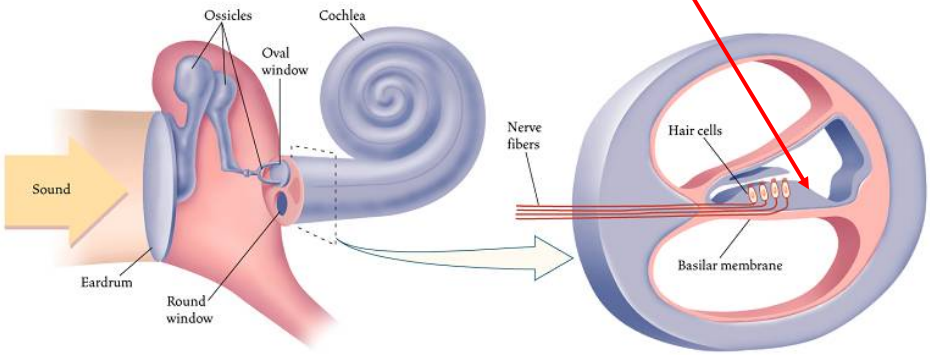

Vibration pattern transferred from the oval window to the fluid-filled cochlea of the inner ear. Sound waves amplified on the way by funnel shape of ear.



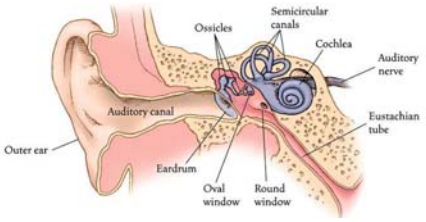

## Sound waves affect the basilar membrane




Cochlea divided into two tubes that are separated by the basilar membrane.

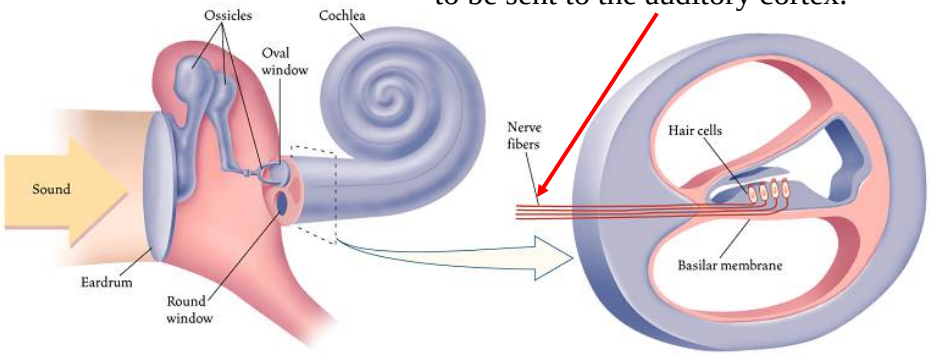


## Basilar membranes moves with the sound wave




Waves transferred to the fluid in the cochlea cause the basilar membrane to vibrate.

As the basilar membrane undulates, <u>hair cells</u> on the membrane are displaced, triggering neural impulses to be sent to the auditory cortex.

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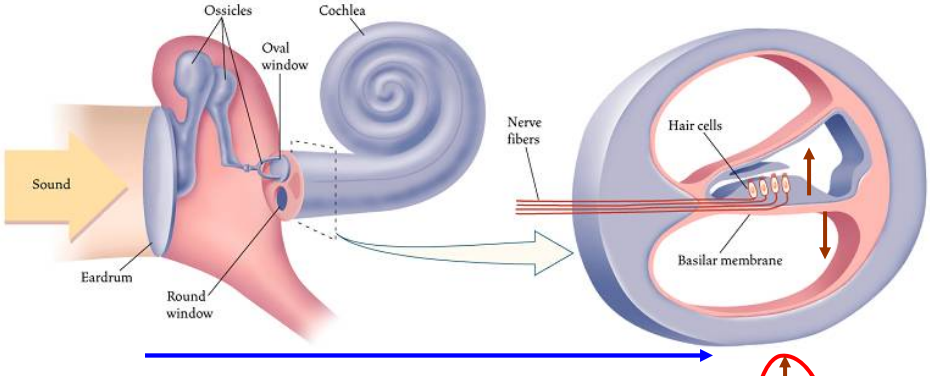
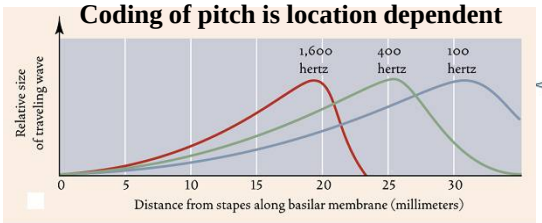
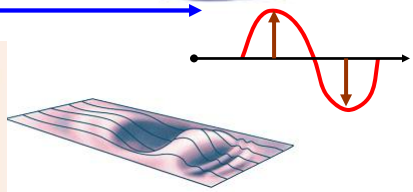



**Coding of pitch is location dependent**



**membrane displacement**

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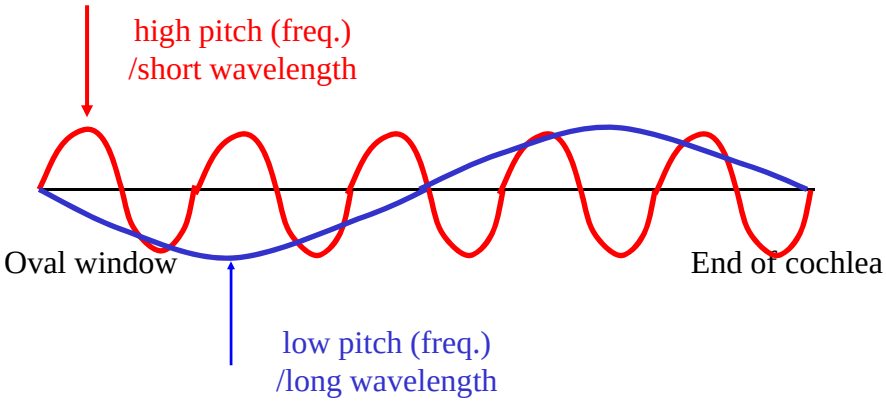
## Basilar Membrane Vibration (unrolled cochlea)

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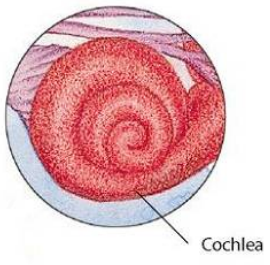
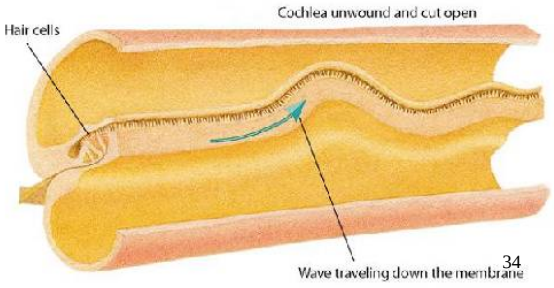
## Place Theory (von Helmholtz)

- Nervous system identifies a sound's pitch by keeping track of the location of movement along the basilar membrane
- High frequency sound → hair cells near oval window
- Low frequency sound → hair calls near end of cochlea

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## The Auditory Pathway

- Sound (**distal stimulus**) picked up by outer ear and travels down the auditory canal.
- At end of canal, sound waves vibrate the ear drum.
- Ear drum moves the ossicles of the middle ear.
- Ossicles push up against the oval window, sending ripples through fluid in cochlea of inner ear.
- Basilar membrane undulates in time with the fluid causing hair cells to move (**proximal stimulus**).
- Hair cell stimulated by movement and send neural impulses to thalamus and then on to the auditory cortex.

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## Lecture Outline

**Sensation & Pereception**

- Hearing
- **Vision**

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# Vision

- Eye detects light (electromagnetic radiation)
  - Two properties:
  1. Wavelength → Color
  2. Amplitude → Brightness

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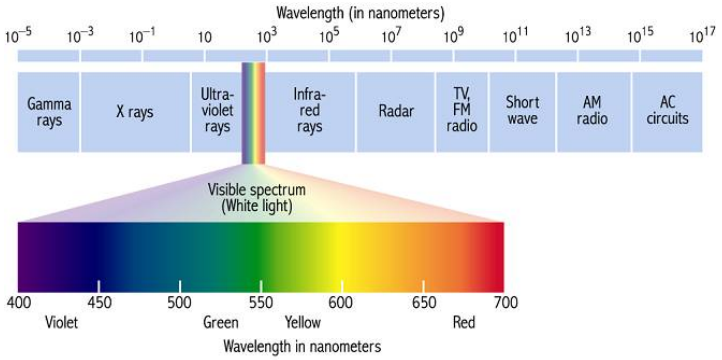
# Vision

- Eye detects light (electromagnetic radiation)
  - Three properties:
  1. **Wavelength → Color**
  2. Amplitude → Brightness

Hue depends on wavelength of light. Visible spectrum runs from 400 nm (violet) to 700 nm (red)

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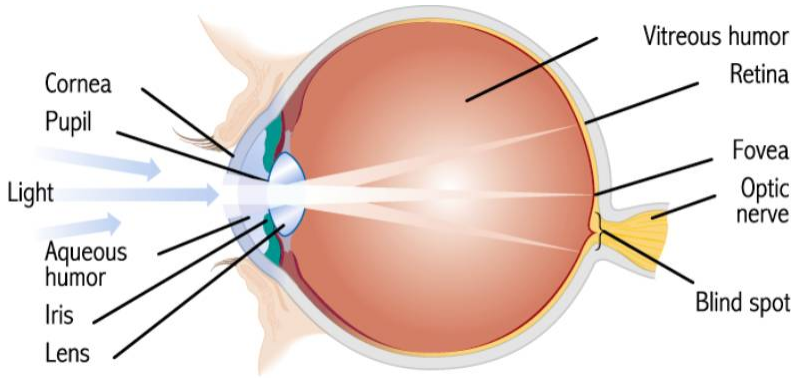
Gathering Light
Distal Stimuli = **light waves**

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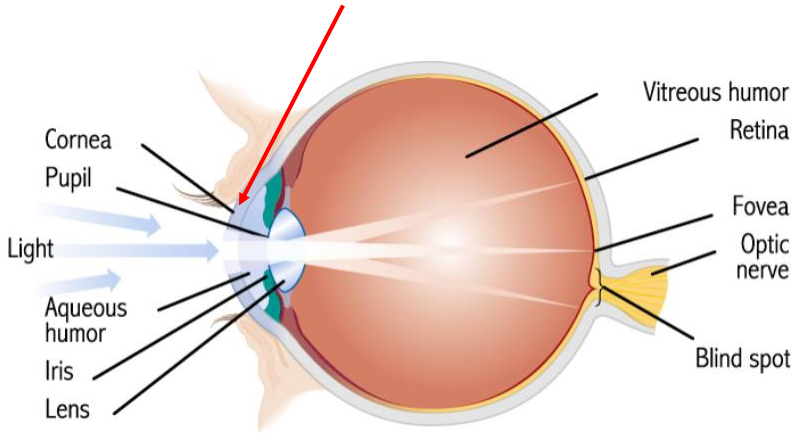
# Gathering Light

Light enters the eye through the cornea, which is a firm transparent covering over the eye

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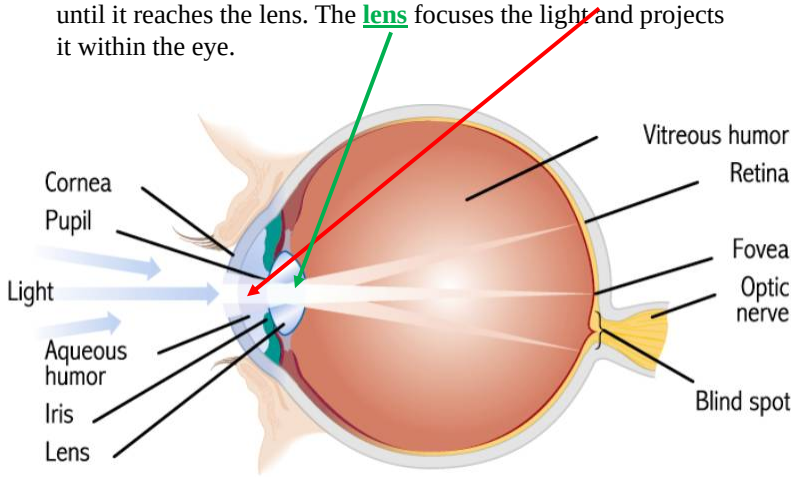
# Gathering Light

The light then travels through the liquid-filled **aqueous humor** until it reaches the lens. The **lens** focuses the light and projects it within the eye.

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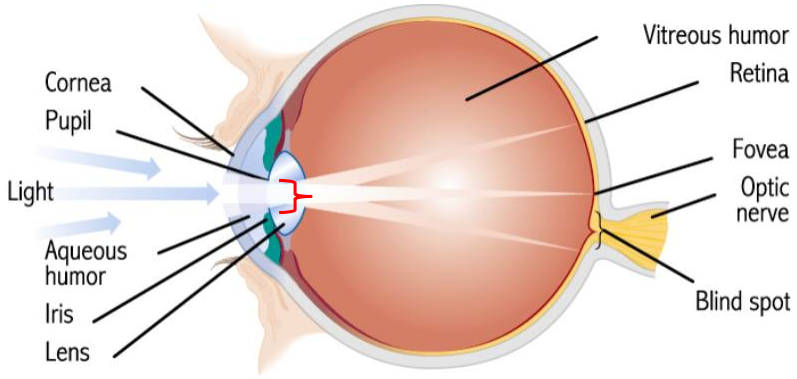
# Gathering Light

The amount of light that reaches the lens is varied by the iris, which is a small colored ring of muscle which constricts or dilates… closing and opening the **pupil**.

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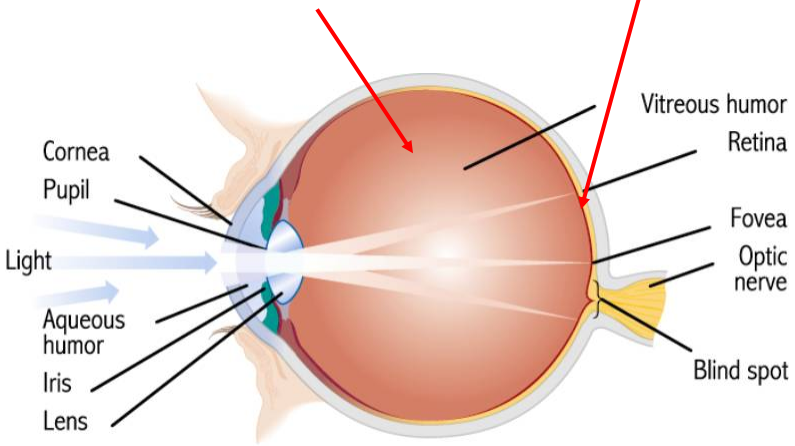
# Gathering Light

Light that passes through the lens is focused on the retina, passing through the vitreous humor along the way.

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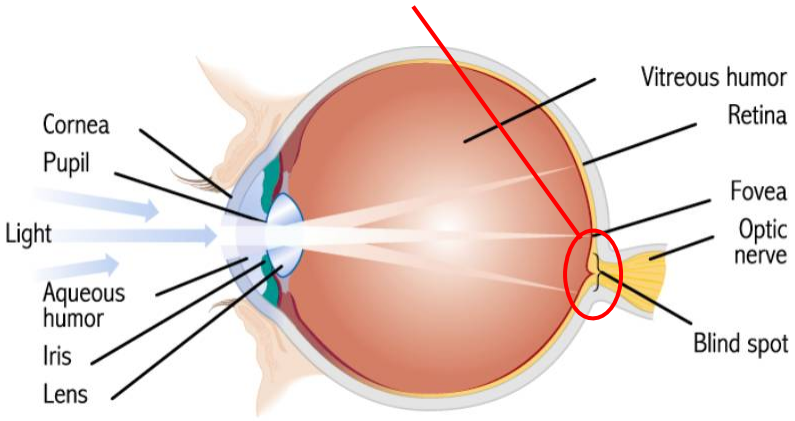
# Gathering Light

The retina contains all of the receptor cells that communicate with the brain. Afferent neurons come out of the retina to form the optic nerve, creating a blind spot in our vision.

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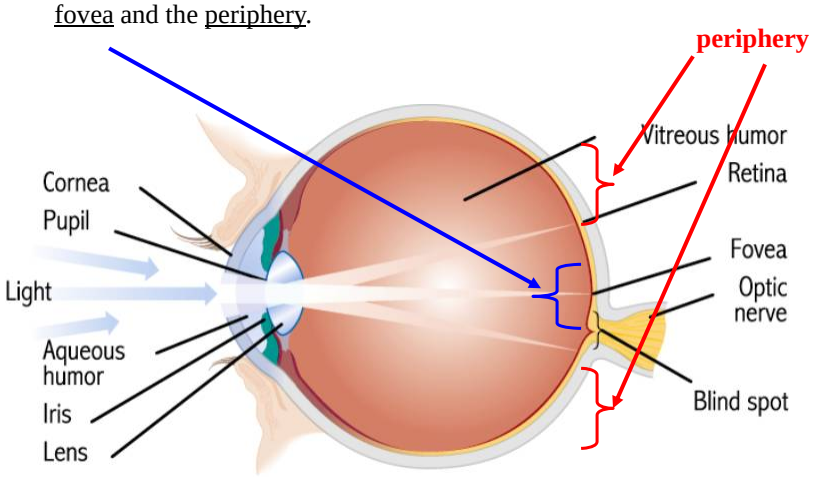
# Gathering Light

When light is projected on the retina, it can fall in two locations… the fovea and the periphery.

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# Central and Peripheral Focus

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## Central and Peripheral Focus

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## Central and Peripheral Focus

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Receptor Cells of Retina Responsible for Transduction

- **Cones**
  - Abundant in the **FOVEA** but become sparse in the periphery
  - About 6 million in each eye
  - **Important for chromatic (color) vision and fine details (a.k.a. acuity)**
  - Require intense light (e.g., day-light conditions)
  - Shaped like a cone

- **Rods**
  - Absent from the fovea but very abundant in the **PERIPHERY**
  - About 120 million in each eye
  - **Important for achromatic (grayscale) vision and detecting movement**
  - Require only minimal light (e.g., twilight conditions)
  - Shaped like a rod

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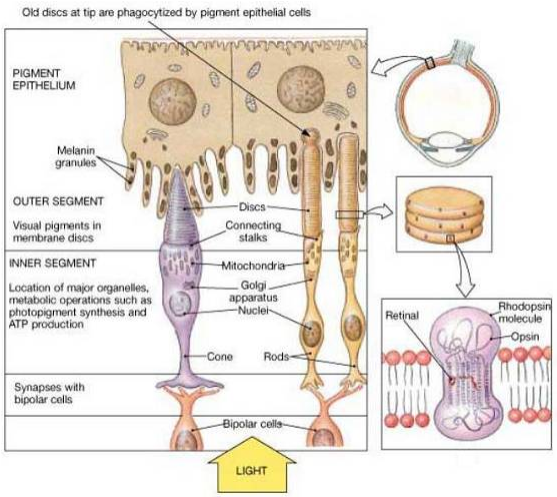
## But how do rods and cones work?




- Light reaches rods and cones
- Photosensitive pigment found in end of receptor cells
- Light changes the shape of the pigment within end of cell, triggering cascade of activity inside receptor cell
- Rods and cones have different pigments

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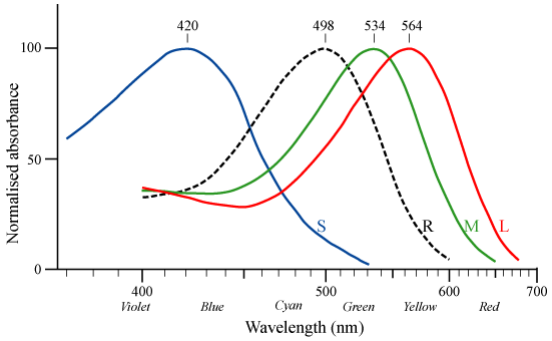
# Cones used for color vision

- Human color vision dependent upon three types of cones
- Pigment in each cone type absorbs reflected light over a range of wavelengths
  - Blue light (~ 420 nm)
  - Red light (~ 564 nm)
  - Green light (~ 534 nm)

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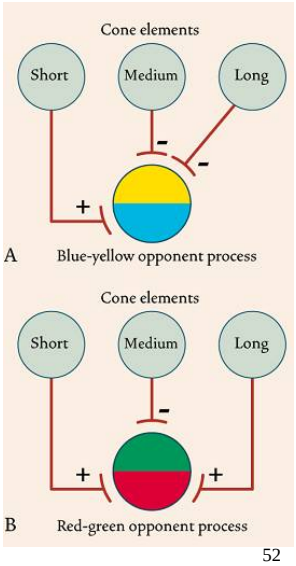
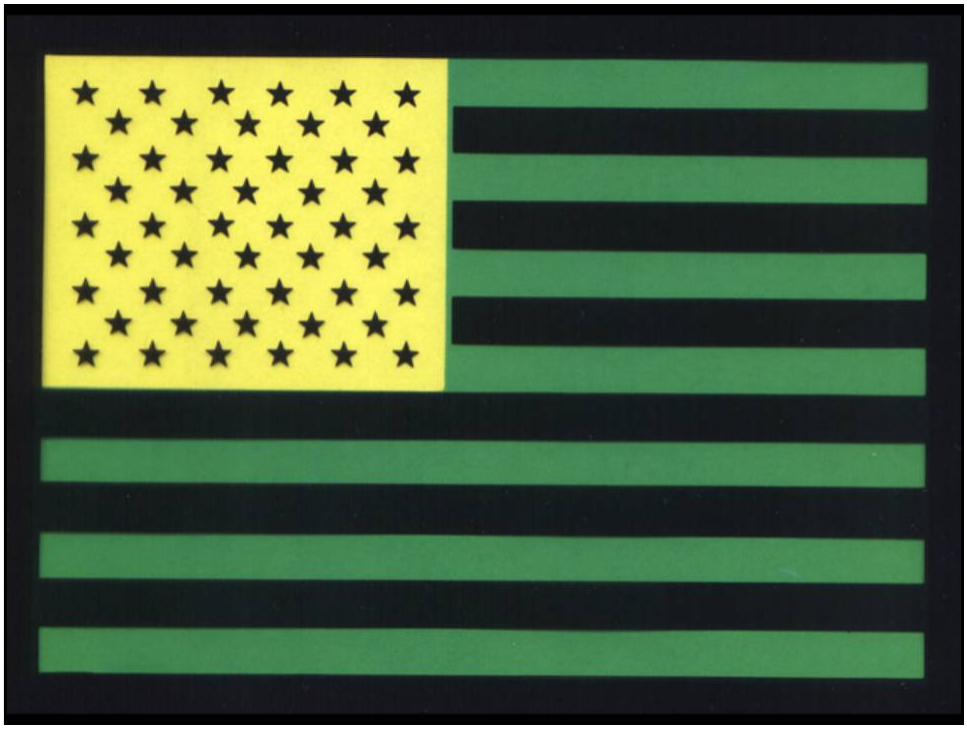
# Opponent-Process Theory of Color Vision

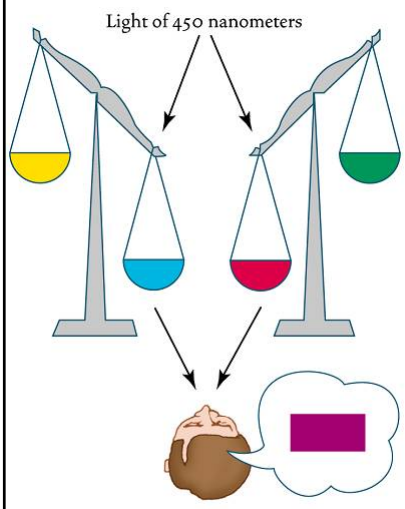
- Proposes 3 pairs of color antagonists:
  - Red-Green
  - Blue-Yellow
  - White-Black
- Three types of cones absorb short, medium, and long wavelength light
- For each opposing color, the level of excitation of the 3 cones determines which color we see.
  - No bluish-yellow
  - No reddish-green




52



Color seen depends on balance of two opponent-processes




**See 450 nm light**

⬇

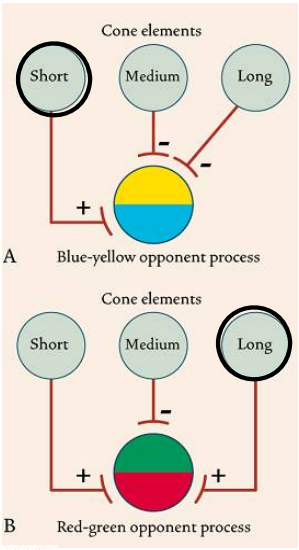
**Activates short λ receptors**

⬇

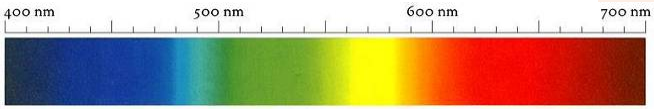
**Blue-Yellow: Excited**

✚

**Red-Green: Excited**




Hue: Blue + Red = Violet

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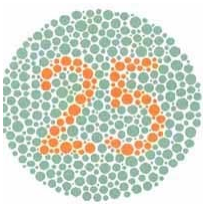
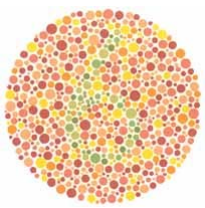
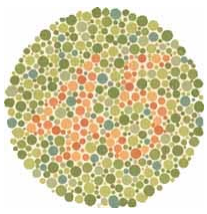
What happens when someone is color blind?

- Men are 250 times more likely to have color blindness than women
- Causes include (a) pigment missing in cones, (b) damage to retina or optic nerve, (c) defective opponent-process, or (d) damage to part of visual cortex
- Red-Green color blindness with difficulty detecting green is the most common







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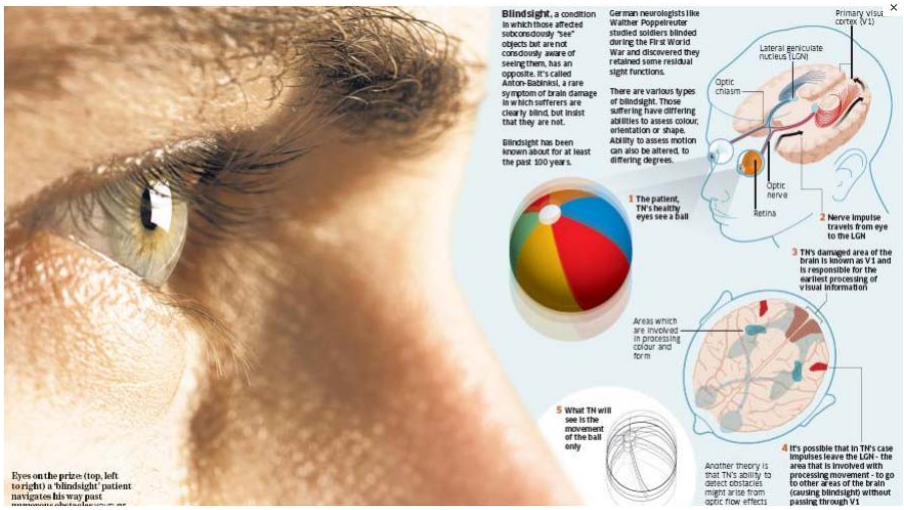
## Blindsight


Blindsight, a condition in which those affected subconsciously "see" objects but are not consciously aware of seeing them, has an opposite. It's called Anton-Babinski, a rare symptom of brain damage in which sufferers are clearly blind, but insist that they are not.
Blindsight has been known about for at least the past 100 years.
German neurologists like Walther Poppelreuter studied soldiers blinded during the First World War and discovered they retained some residual sight functions.
There are various types of blindsight. Those suffering have differing abilities to assess colour, orientation or shape. Ability to assess motion can also be altered, to differing degrees.
Primary visual cortex (V1)
Lateral geniculate nucleus (LGN)
Optic chiasm
Optic nerve
Retina
1 The patient, TN's healthy eyes see a ball
2 Nerve impulse travels from eye to the LGN
3 TN's damaged area of the brain is known as V1 and is responsible for the earliest processing of visual information
Areas which are involved in processing colour and form
4 It's possible that in TN's case impulses leave the LGN - the area that is involved with processing movement - to go to other areas of the brain (causing blindsight) without passing through V1
5 What TN will see is the movement of the ball only
Another theory is that TN's ability to detect obstacles might arise from optic flow effects
Eyes on the prize: (top, left to right) a 'blindsight' patient navigates his way past

http://www.independent.co.uk/news/science/out-of-mind-out-of-sight-the-blind-man-who-can-see-obstacles-2090303.html

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## Lecture Outline

### Sensation & Perception

- **Depth Perception**
- Motion Perception
- Shape/Form Perception

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## Depth Perception

- A distal visual stimulus is three-dimensional, but a proximal stimulus is a two-dimensional image
- Perception becomes 3-D via the use of depth cues that bias how the image is interpreted
- Actual distance between observer and distal stimulus approximated using cues from environment
  1. Binocular cues
  2. Monocular cues

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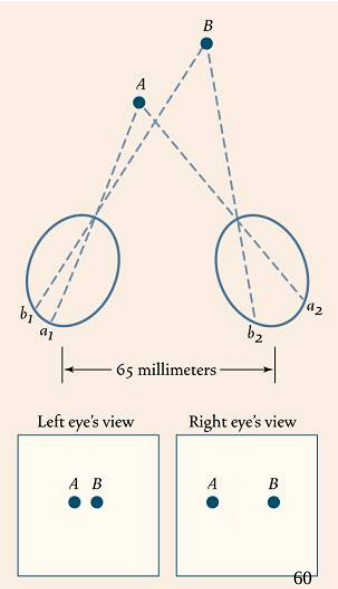
## Depth Perception: Binocular Cues

- Each of us have two eyes, so we take in information from two different physical perspectives
- Binocular (retinal) disparity: difference in view of object from each eye
  - Difference less pronounced when object is more distant

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# Depth Perception: Binocular Cues

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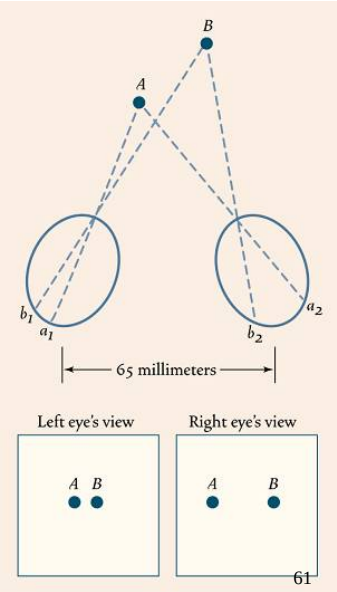
  -

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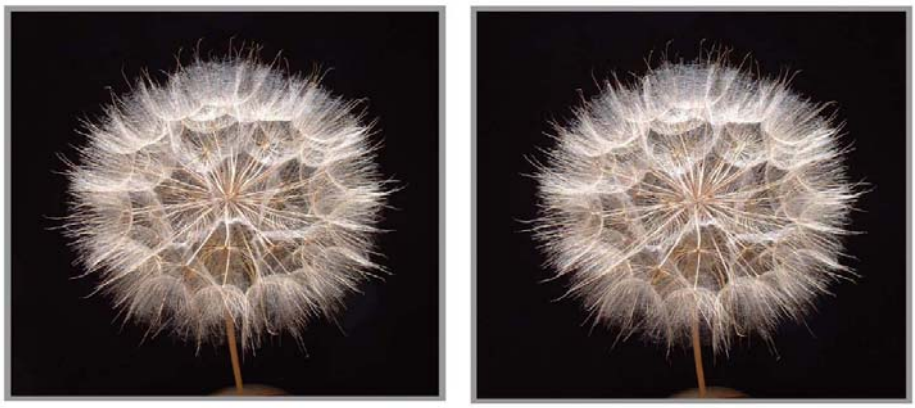

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## Depth Perception: Binocular Cues

- Each of us have two eyes, so we take in information from two different physical perspectives
- Binocular (retinal) disparity: difference in view of object from each eye
  - Difference less pronounced when object is more distant
- Convergence: neuromuscular cue in which the two eyes move inward toward the object

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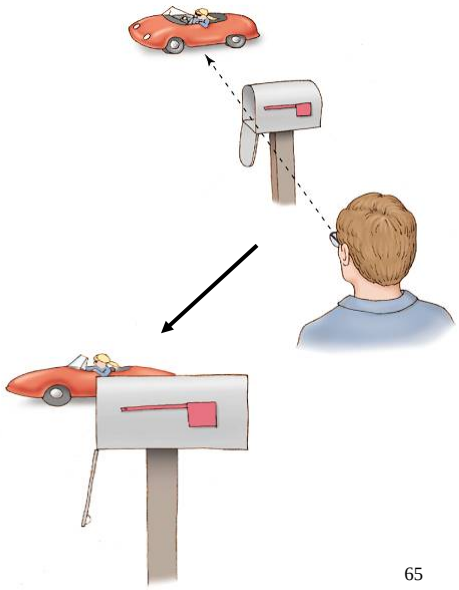
## Depth Perception: Monocular Cues

- Depth perception does not require the use of two eyes
- Cues exist that require only one eye
- Often called pictorial cues
- Interposition: object that is farther away is blocked by a nearby object



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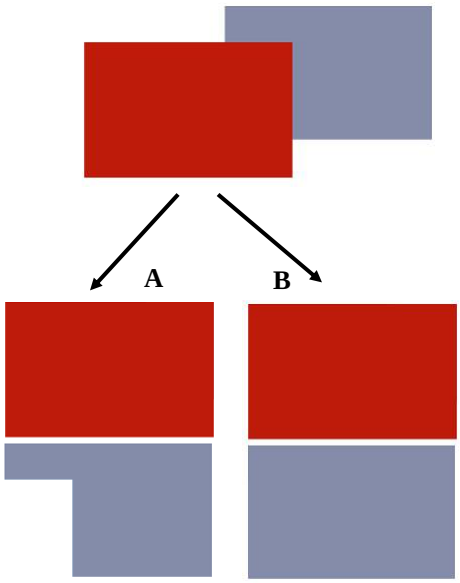
## Depth Perception: Monocular Cues

- Depth perception does not require the use of two eyes
- Cues exist that require only one eye
- Often called pictorial cues
- Interposition: object that is farther away is blocked by a nearby object
  - Simplest explanation perceived



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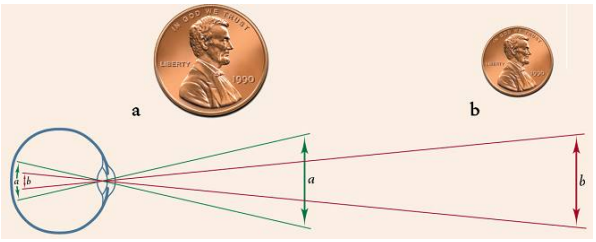
# Depth Perception: Monocular Cues

- Linear Perspective

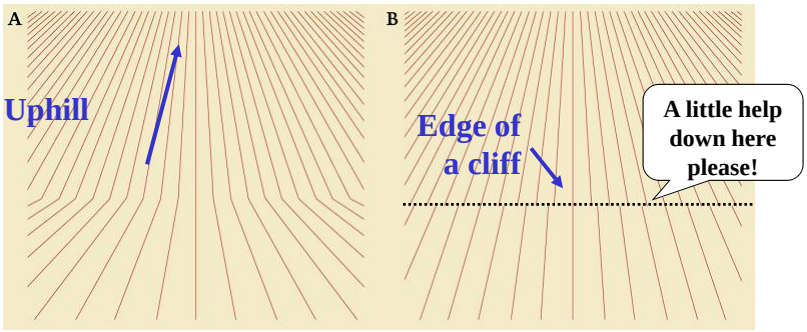



Objects appear smaller if viewed from a distance (a.k.a. **relative size cue**)

Parallel lines seem to converge as they recede into depth

# Depth Perception: Monocular Cues

- Texture gradient — Perceived changes in surface texture that depend on how far the the observer is from the object




We see a pattern of continuous change with the elements of the texture becoming smaller and smaller as they become more and more distant.

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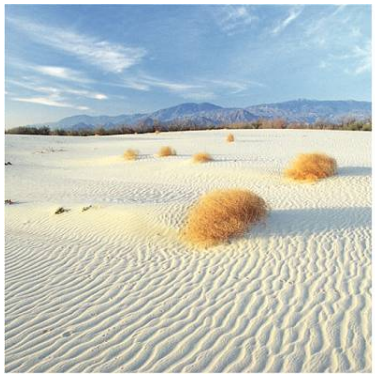
# Depth Perception: Monocular Cues

- Texture gradient — Perceived changes in surface texture that depend on how far the observer is from the object



We see a pattern of continuous change with the elements of the texture becoming smaller and smaller as they become more and more distant.

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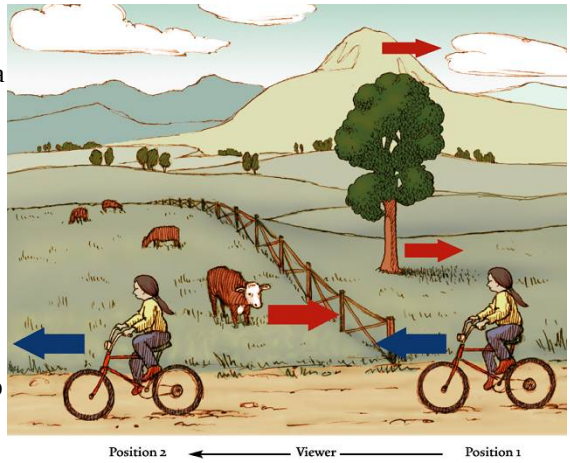
## Motion Parallax: Motion as a Cue for Depth

- When an observer moves, images of nearby objects move more across the retina than the images of objects that are farther away

- Speed = **distance** / time
  - Near and far objects move for ***same amount of time***
  - **Nearby** objects move a **greater distance** and so appear like they are faster

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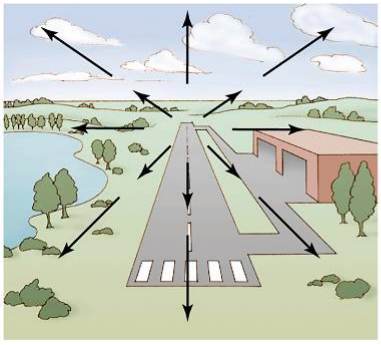
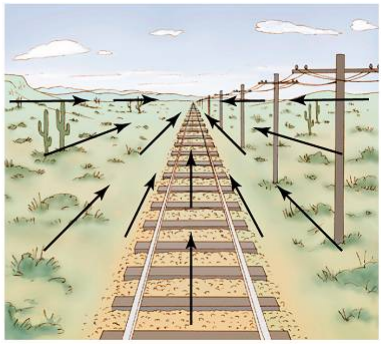
# Optic Flow: Motion as a Cue for Depth

- When an observer moves…
  - the object's retinal image gets bigger as we approach the object
  - the object's retinal image gets smaller as we back away from it



Pilot landing



Track at back of train

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## Lecture Outline

**Sensation & Perception**

- Depth Perception
- **Motion Perception**
- Shape/Form Perception

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## Motion Perception

- Objects attached to dynamic events
- Perceiving movement important for understanding function: what something is doing (i.e, how it works)
- Motion perceived via…
  1. ***Activity of cells*** in visual system sensitive to motion in field monitored by receptor cells
  2. Stable sequences in time that ***resemble intention***
  3. ***Adjustment*** in information processing by visual system ***for eye movements***
  4. ***Illusions***

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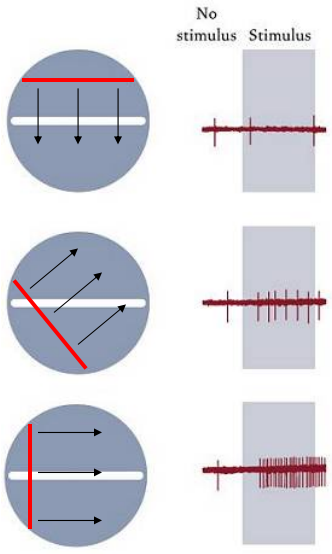
## Retinal Motion

- Image move across retina
- Info passed to motion detector cells in primary visual area
- Cells fire when object moves in a specific direction across their receptive field

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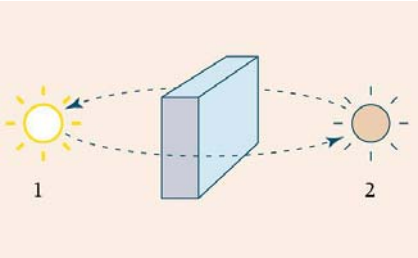
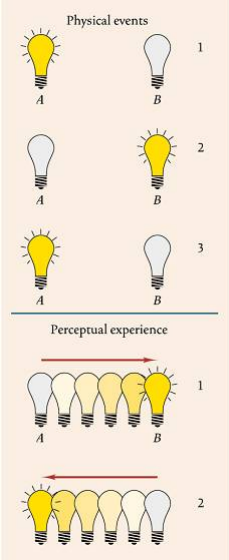
## Apparent Movement

- Stationary stimuli flash on and off at appropriate positions and at appropriate intervals of time
- Obstacle to apparent movement rationalized (e.g., jump over or orbit around)

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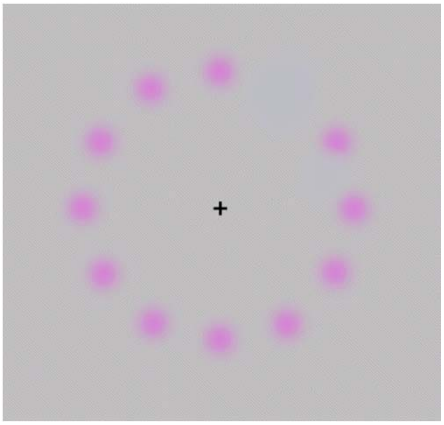
## Lilac Chaser



***Found on wikipedia.org***

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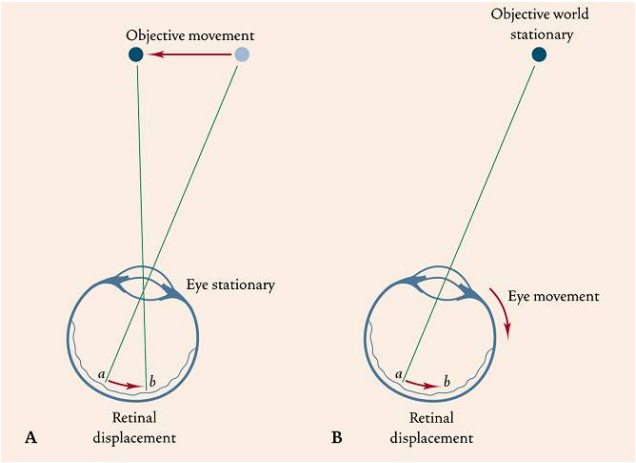
# Eye Movements versus Tracking

- Brain corrects the interpretation of the image on the retina for eye movements when looking at stationary objects
- When we do track objects or when we move our head (i.e., voluntary eye movements), the brain uses displacement of image to measure distance and speed

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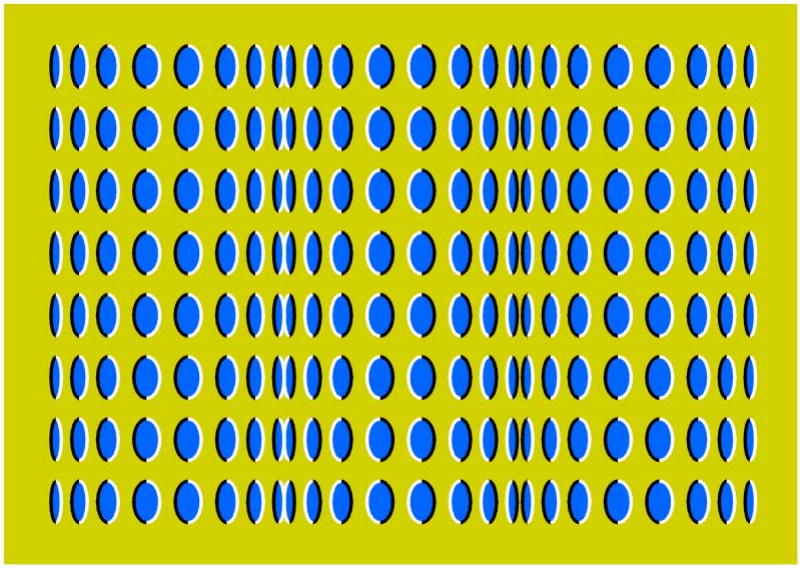
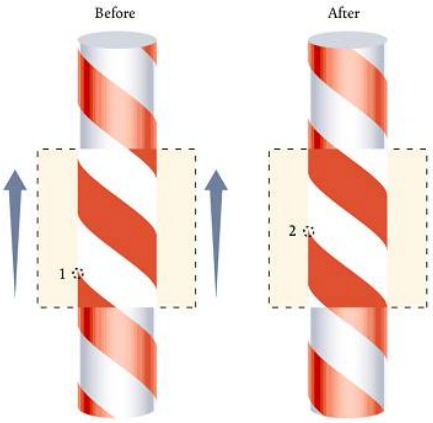
# Illusions of Motion



## Correspondence Problem

- Problem of determining which elements of our current view correspond with elements from an earlier view
- Barber-Pole Illusion
  - A spot on the barber pole stripe can be perceived as moving **upward** over time as the pole rotates…

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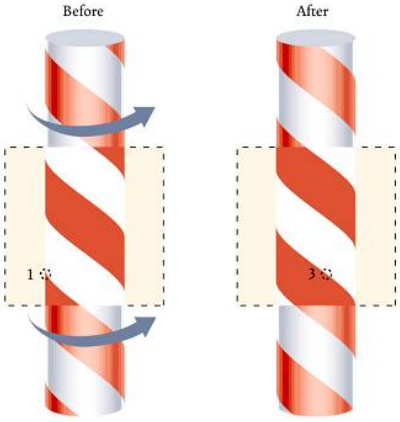
## Correspondence Problem

- Problem of determining which elements of our current view correspond with elements from an earlier view
- Barber-Pole Illusion
  - … or the spot can appear to **move from the left border of the pole to the middle** as more of the area of stripe behind the spot comes into view

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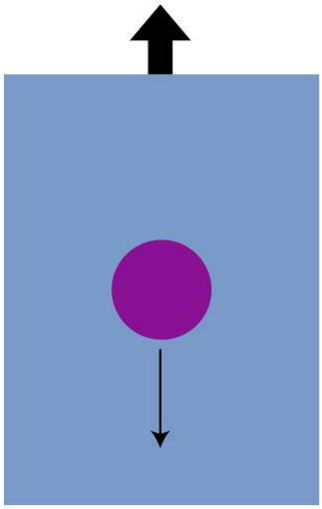
## Induced Motion

- Illusion that a stationary object is moving when the framework (background) surrounding it is really moving
- Occurs because small objects typically move across larger backgrounds
- Object approaches edge… but edge is moving



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## Induced Motion

- Illusion that a stationary object is moving when the framework surrounding it is really moving
- Occurs because small objects typically move across larger backgrounds
- Expect all of the plates and food to come crashing down off of table

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## Induced Motion

- Illusion that a stationary object is moving when the framework surrounding it is really moving
- Occurs because small objects typically move across larger backgrounds
- Can perceive motion if you're on a train that is stationary while train out window pulls away

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## Lecture Outline

**Sensation & Perception**

- Depth Perception
- Motion Perception
- **Shape/Form Perception**

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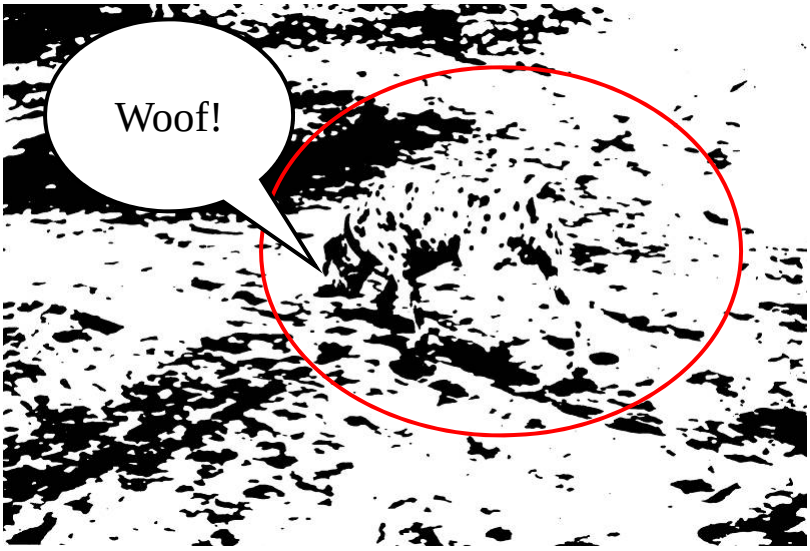


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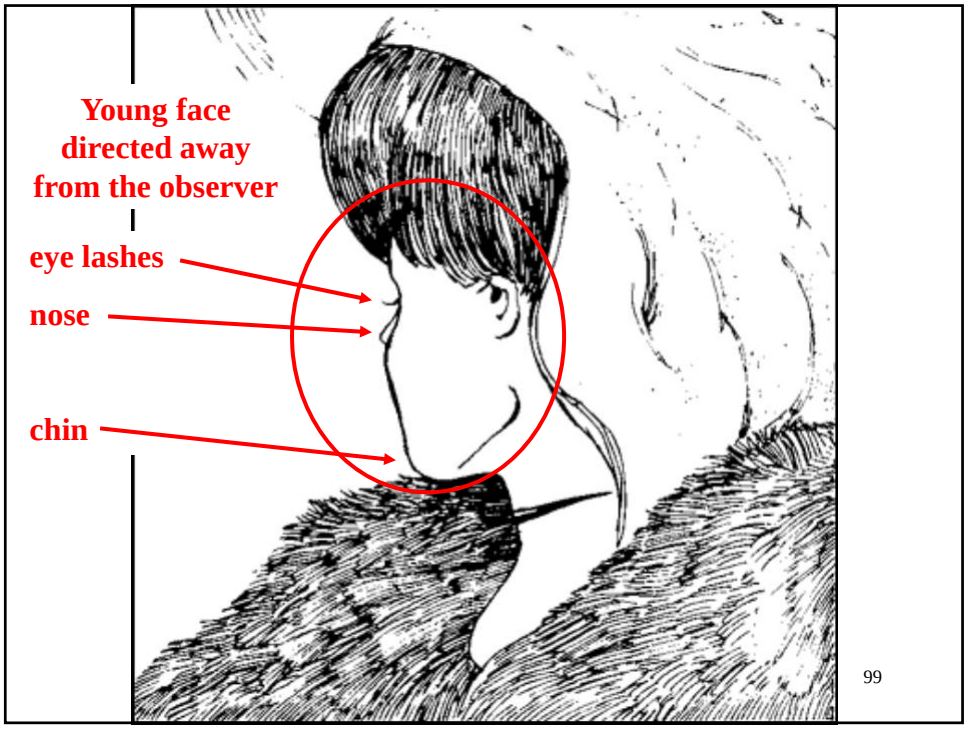
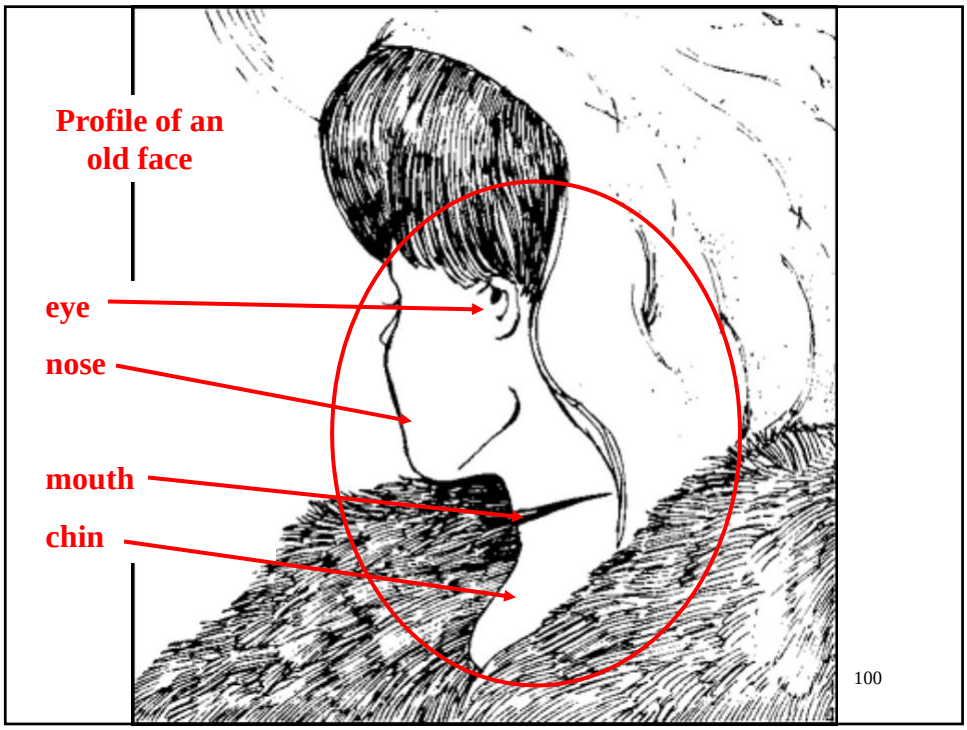
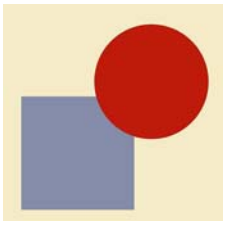

Young face
directed away
from the observer
eye lashes
nose
chin
99

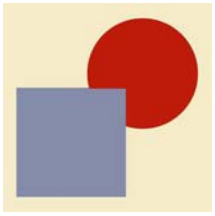

Profile of an
old face
eye
nose
mouth
chin
100

# Form Perception

- Involves perceiving and recognizing the identity of an object
- Two approaches to processing visual stimuli:
  1. Bottom-up: object is sum of its parts
  2. Top-down: object matches pre-existing category
- The two approaches interact
  - Object's identity remains the same even at different views
  - Identity based on category membership implies that certain features exist even if not part of an object's proximal representation



**The simplest rule for organization always wins**



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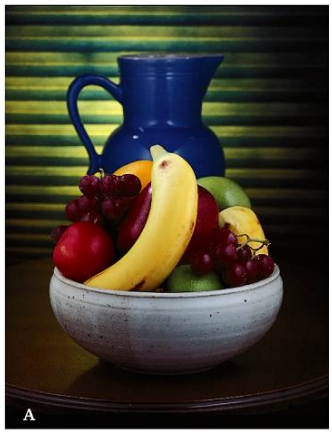
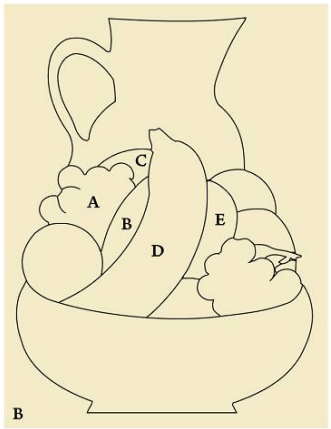
# Visual Segregation

- This step involves locating an object's boundary, so that the perceiver can discern where one object stops and the next begins

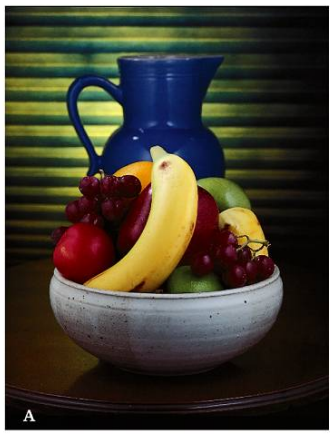


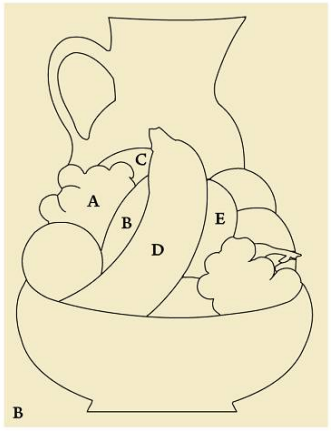




02

# Visual Segregation

- Involves two steps:
  1. Separating the object (or figure) from its background (or ground)
  2. Grouping or organizing visual input that goes together




03

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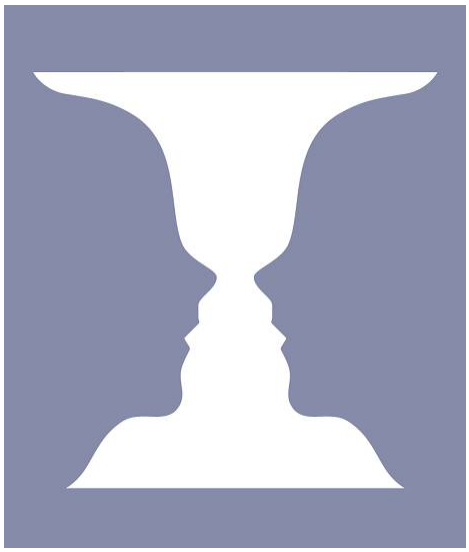
## Visual Segregation: Figure and Ground

- Visual segregation requires that we separate the figure from the ground
- Figure: object in the display with defined edges
- Ground: background behind object
- Reversible figure: faces vs. vase
- Figure processed more carefully for detail than is ground



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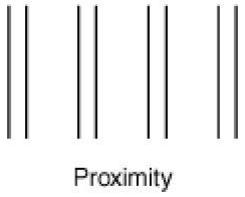
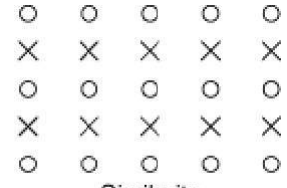
## Visual Segregation: Perceptual Grouping

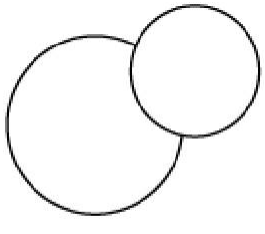
- Visual segregation requires that we determine what elements of the display belong together as a unit and which do not belong
- Grouping based on the Gestalt laws of perceptual organization



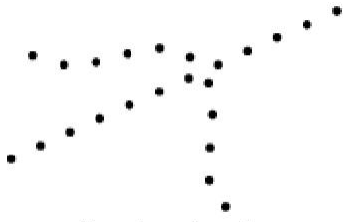
Proximity



Similarity



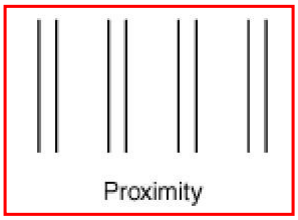
Closure



Good continuation

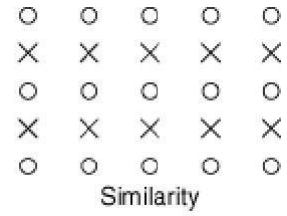
## Visual Segregation: Perceptual Grouping

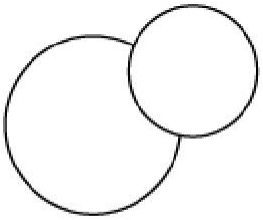
- Visual segregation requires that we determine what elements of the display belong together as a unit and which do not belong
- Grouping based on the Gestalt laws of perceptual organization

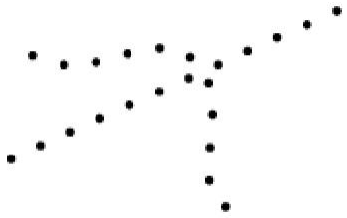



**Proximity**

**The closer two figures are to each other, the more that they tend to be grouped perceptually**



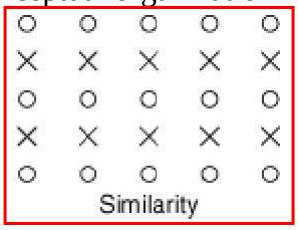



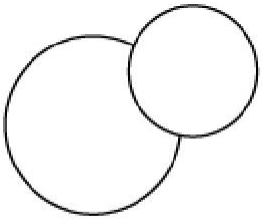

## Visual Segregation: Perceptual Grouping

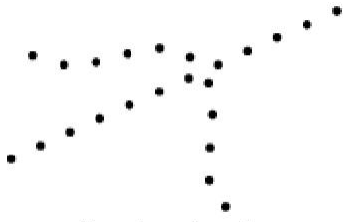
- Visual segregation requires that we determine what elements of the display belong together as a unit and which do not belong
- Grouping based on the Gestalt laws of perceptual organization

**Similarity**

**Elements that are similar are more likely to be grouped together**

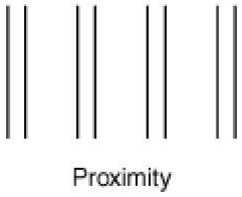


## Visual Segregation: Perceptual Grouping

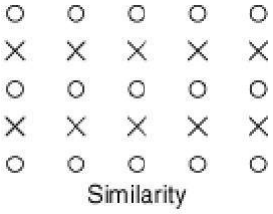
- Visual segregation requires that we determine what elements of the display belong together as a unit and which do not belong
- Grouping based on the Gestalt laws of perceptual organization



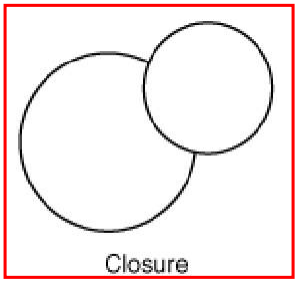
Proximity

**Closure**

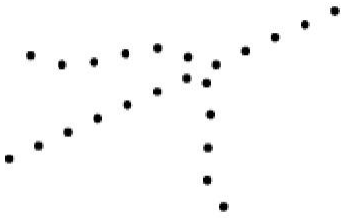
**If two figures overlap, hidden aspects of the figure are inferred to exist**



Similarity



Closure



Good continuation

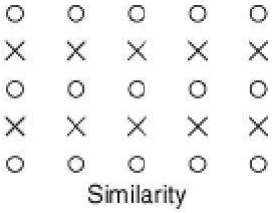
## Visual Segregation: Perceptual Grouping

- Visual segregation requires that we determine what elements of the display belong together as a unit and which do not belong
- Grouping based on the Gestalt laws of perceptual organization

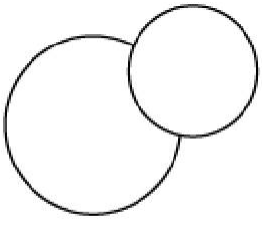
Proximity

**Good Continuation**

**Direction of lines and contours appear to be altered as little as possible**



Similarity



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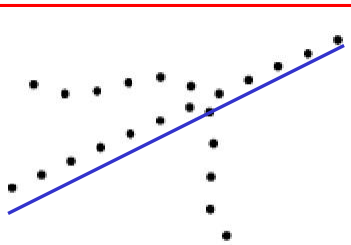

Good continuation

# Lecture Outline

**Chapter 3 : Sensation & Perception**

- Bottom-Up and Top-Down Processing
- Hearing
- Vision
- Shape/Form Perception

**What holds everything together?**

**Our focus of attention**
**- Requires effort**
**- Our attentional capacity is limited**

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